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Spatial Data Infrastructures: Some Technological Issues

Víctor Pascual-Ayats

The article describes the main technological issues related to the implementation of a Spatial Data Infrastructure (SDI), with particular reference to the Spatial Data Infrastructure of the Spanish region of Catalonia (referred to here by its Spanish acronym, IDEC).

Keywords: Geographic Information, Map Server, Metadata, OGC, SDI.

1. What is an SDI?

The SDI (Spatial Data Infrastructure) concept arose in the late 90's as a political initiative in the United States [1] to ensure interoperability between geographic information generated by different federal agencies.

In Europe, the directive 2007/2/EC, known as the INSPIRE (Infrastructure for Spatial Information in the European Community) directive [2] defines the framework on which European SDI initiatives should be based.

There are a number of different definitions to describe an SDI, but perhaps the most accurate and most commonly used is the following, from the Federal Geographic Data Committee (FGDC): "*the framework of technologies, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve the utilization of geospatial data*".

The above definition suggests that an SDI is not only a technological implementation but also has a very large communication component: not only server-to-server communication, but also institution-to-institution, department-to-department and, in short, person-to-person communication, in order to establish collaborative frameworks to facilitate the sharing and description of, and access to, geographic data.

We should think of the implementation of an SDI as being multi-scale in nature, as it can be implemented at a European, national, regional, or even municipal level. Each level is responsible for ensuring interoperability with all other levels.

Thus the mission of the Spatial Data Infrastructure of Catalonia (IDEC) and, in particular, its support centre (C.S.IDEC) is to encourage institutions in Catalonia to describe and share their geographic information, in a manner that is not only interoperable within Catalonia but also with other regional, national, and European SDIs.

1.1 The INSPIRE Directive

The INSPIRE directive establishes a legal framework for the implementation of a European Spatial Data Infrastructure involving the 27 member states.

INSPIRE focuses on environmental policy, but it can also be extended to other sectors such as agriculture, transport, and energy.

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Under INSPIRE the member states, who are responsible for applying the directive in their respective territories, describe and open up their environmental data to other members using technology based on geospatial standards. "Describe" here means not only to provide a description (metadata) of the geospatial information itself, but also to show how it is structured (data model). This should not only allow the data to be visualized jointly with other information, but also ensure interoperability between sets of data.

A typical scenario might be a forest fire affecting the border area between two states. First we would need to visualize the forested areas of the two states and then merge the two layers of information (with different data models) in order to obtain a single layer enabling us, with the aid of other variables, to model the possible propagation of the fire.

The technical coordination of the directive in Europe is currently the responsibility of the Joint Research Centre (JRC), which is focusing its efforts on:

- Metadata creation.
- Spatial interoperability between data and services.
- The creation of a network of services.
- Policies for sharing data and services.
- The coordination and creation of indices (metrics) for monitoring services.
- The formulation of implementation rules.

2 Technology and Standards

In an optimal scenario, all SDI users should be able to

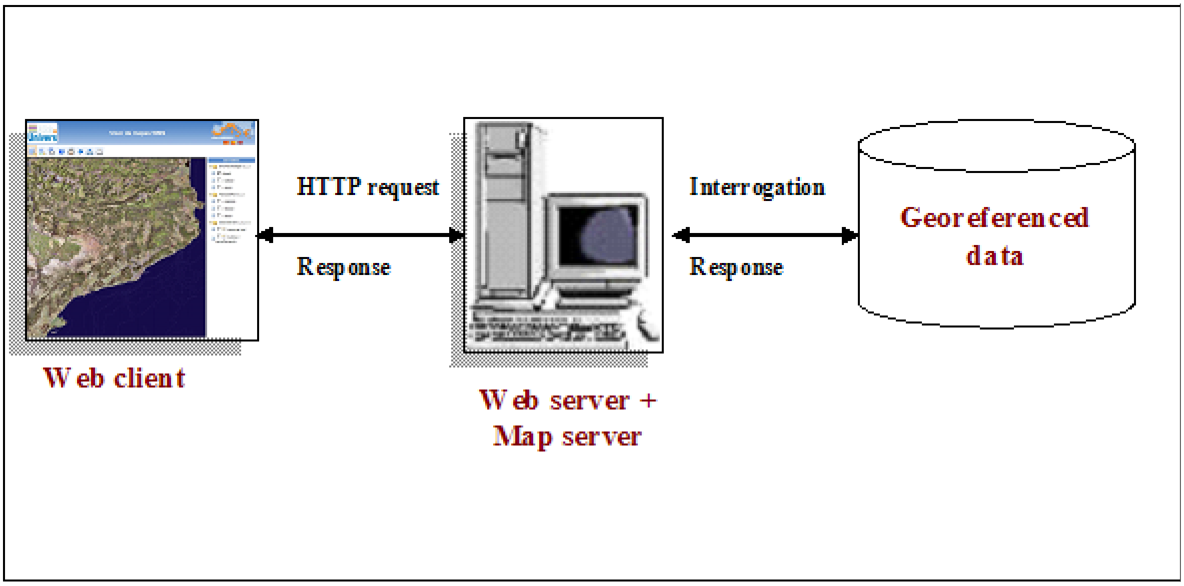

Figure 1: Diagram Showing How a Map Server Works.

find out, say, what geographic information exists in a particular area of the territory in question, view this information, and finally, if it is of interest, download it.

To achieve this goal any SDI worth its salt should:

a) Orient its architecture towards services (SOA).

Two of the basic principles of any SDI are that geographic data should not be replicated and that no large centralized databases should be created. An SDI should pursue a distributed model in which each department or entity is responsible for its own data and undertakes to describe it and make it available to all other interested parties. Thus in Catalonia, for example, one of the first departments to be incorporated within the IDEC was the Department for the Environment and Housing, which made a large percentage of the geographic information they produce available to users. Therefore, when users access one of its layers they are assured that the information they see is up to date and managed by the same agency that provides it. This may seem to be a glaringly obvious thing to do but, before IDEs reached public administrations, this kind of procedure was conspicuous by its absence.

b) Implement applications that enable geographic information to be searched, visualized and processed.

Among these applications, which lie at the core of all SDIs, are map servers, a set of geographic services and, perhaps the most important element of all, a metadata catalogue.

The metadata catalogue is a registry which contains the inventory of all available geographic information in the territory covered by the SDI.

Implementing a catalogue may be a tedious and thankless task but it is vital to the success of an SDI. The job basically consists of locating all possible producers of cartographic data (departments, agencies, companies, or even universities) and convincing them to make an inventory of all their geographic information and to describe it following a standard procedure. This is what we call "creating metadata".

This metadata, which is stored in eXtensible Markup Language (XML) encoded files in accordance with the International Standards Office (ISO) standard 19115, are loaded into the metadata catalogue so that they can be interrogated by any user. It has to be said that the creation of metadata is not an easy task and involves describing fields such as map creator, creation date, revision date, accessibility, information formats, quality, distribution, and the coordinate box corresponding to the information described.

One special feature of metadata catalogues is that they can be interrogated spatially (e.g. "*Give me all existing geographic information relevant to the course of this river*"). Some of them, for example IDEC's metadata catalogue, go beyond being a mere repository for metadata and permit the registration of transformation templates which can be used to combine geographic data models, geographic object requests, and cartographic representation methods, all as part of IDEC's distributed geoservices.

Once the geographic information has been described and inventoried, SDI member entities are asked to allow the information described to be visualized, basically via a Web browser. This is done by using map servers, which are server language based applications able to run on a Web server and enable georeferenced information (containing coordinates) to be visualized and geoprocessed.

Finally there is a mixed bag of complementary services, which are encapsulated so as to be remotely callable, either independently or jointly with other services, which carry out small greoprocesses such as:

- Geocoding: To return a coordinate pair from a postal address.

- Gazetteer: To locate toponyms.
- Routings: To calculate routes.
- Conversion of coordinates.
- Spatial analysis.
- Conversion between geospatial formats.

c) Adopt geospatial interoperability standards in order to facilitate communication between components.

As has already been mentioned, the description of metadata is based on an ISO standard of the 19 family, devoted to the geospatial world. But with regard to communication interfaces between servers, and between clients (e.g. a Web browser) and servers, there is a consortium called the Open Geospatial Consortium (OGC) [3] whose job it is to decide on the specifications to be used.

OGC's role in the geospatial world is not dissimilar from W3C's role in the standardization of the World Wide Web. OGC is a not-for-profit consortium created in 1994 and made up of over 400 enterprises, governmental agencies, and universities, which together work towards developing open specifications.

The purpose of these specifications is to promote geospatial interoperability. The success of these specifications lies in the fact that they are promoted and created by the same companies that will later implement them in their commercial products.

A specification is a technical document describing the communication interfaces between servers and how they are to be implemented. These specifications make no mention of the architecture, platform, or programming languages to be used. Before being considered as an OpenGIS Implementation Specification, each document must be developed and tested by various working groups within the OGC and then put to a vote.

One of the most commonly used specifications is Web Map Service (WMS). The purpose of WMS is to enable the superimposed visualization of complex geographic information distributed over various servers. A client may request other servers which are also based on this specification in order to search for geographic information. Once the data is found, the client may make use of it simultaneously and visualize different geographic data from different servers in the same environment. Each request contains a set of specific parameters defined by the WMS specification which are understood by all map servers that meet the specification.

Thus, when we say a map server is standard and is WMS compliant, it means that it the server is capable of responding to such requests.

3 The Spatial Data Infrastructure of Catalonia (IDEC)

IDEC [4] was created under the auspices of Law 16/2005 [5] (which had existed as a draft bill since 2002), passed by the Parliament of Catalonia. The law takes on board the principles of the European INSPIRE directive, adopting all its implementation rules and guidelines. The IDEC Support Centre, a unit of the Cartographic Institute of Catalonia (ICC) [6], is responsible for the development of IDEC and compliance with relevant legislation.

It is currently considered to be one of the most advanced IDEs in Europe [7] and is a benchmark development in terms of its implementation and dissemination.

Its metadata catalogue has over 20,000 geographic information references from over 90 different agencies and

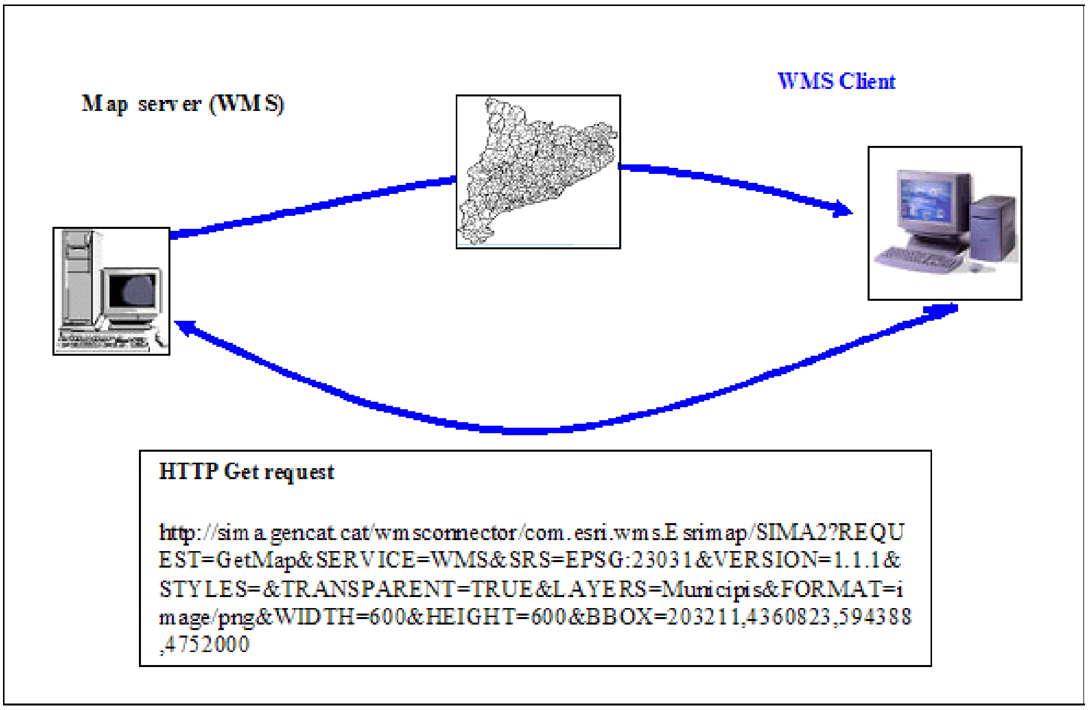

Figure 2: Example of WMS Functionality.

departments. It has a network of over 100 map servers with more than 4,000 available layers to enable the creation of sectoral IDEs.

Sectoral SDIs are spatial data infrastructures on specific topics. They deliver practically the same services as the IDEC but they target a specific topic or sector.

From a technological point of view a sectoral SDI has a set of accessible OGC services, selected in accordance with the particular domain of specialization, and in many cases they have a metadata catalogue which is limited to information relevant to that domain. Both services are available via a geoportal which is specific to the domain in question.

At IDEC's geoportal, there are currently references to three sectoral SDIs:

- **SDI Local.** This is a geoportal created for the AOC (Open Administration of Catalonia) to provide Spatial Data Infrastructure services to local authorities in Catalonia.
- **SDI Costas.** The purpose of this geoportal is to enhance and increase accessibility to information about the coast of Catalonia for the entire community of users, in order to make their participation in the management and transformation of the coast more active and better documented. It has a map server which provides access to the maps of the ICC, the Department of the Environment, the Centre for Ecological Research and Forestry Applications (CREAF), etc. and a metadata catalogue to facilitate information searches related to the coast of Catalonia.
- **SDI-Univers.** The SDI-Univers project is led by the Secretariat for Telecommunications and the Information Society (STSI) and has as its mission the establishment of a university-oriented SDI to promote the accessibility to and interoperability of a large amount of geographic information within the IDEC network.

The purpose of these entities is twofold:

- To produce metadata from the available geographic information and publish it in the catalogue.
- To post georeferenced map layers on WMS servers for them to be incorporated into the SDI.

4 SDI Versus Google

Google has made a tremendous impact on the geospatial visualization scene with its two star products, Google Maps and Google Earth, to such an extent that some public administrations have decided to use their services to make their information available to end users.

Why create ISO metadata and use metadata catalogues? Google does all the indexing, finds everything, and even does it faster. Why use standard map servers? Google can store my information (Google MyMaps) and works faster.

In answer to those two questions we need to bear in mind that an SDI is a network of open services (visualization, geoprocesses, downloads, etc.) based on interoperable standards and can therefore be accessed and exploited using any other standard technology, but also by using Google applications.

There are bridges between the OGC and Google, some of them implemented by Google itself (WMS connection in Google Earth), others by concerned users (libraries to connect WMS in Google Maps), or even at the instance of the OGC itself (converting Google's Keyhole Markup Language (KML) to an OGC standard).

Meanwhile, not all the indexed information delivered by Google Maps or Google Earth can be incorporated as a service in other applications outside Google. In other words, Google does not provide connection protocols permitting unrestricted access to public content created by users. There is no reciprocity (neither need there be any); Google is a private company offering its services to its users and to a large extent lives off advertising revenue.

Another aspect in which Google has had a very positive impact is the way it displays a map on a Web page. For the first 15 years, map servers would display data "raw" in the server, and the clients (Web applications) would display a small map surrounded by myriad buttons and options that were useless for most users.

Then Google Maps arrived; at server level it sliced the map up into tiles and predefined visualization scales. At a client level, the map took over the screen, the buttons were reduced to their minimum expression, and the request cache provided a level of usability and speed never before seen.

Currently all applications for visualizing maps are implementing this way of presenting maps, the way that Google Maps does. Google Maps marks a watershed in the way maps are presented on the Web.

5 Conclusions

Once the technology has been established and as much geographic information as possible has been made available to users, we would consider an SDI to be a real infrastructure when new applications and products using its resources start being built.

One of the greatest challenges facing IDEs today is the need to adapt them to the Web 2.0, and to make the user not just a consumer of resources but also a producer and publisher of information.

References

[1] Office of Management and Budget. Circular A-16, <http://www.whitehouse.gov/omb/circulars/a016/print/a016_rev.html#background>.

[2] INSPIRE directive. <http://inspire.jrc.ec.europa.eu/>.

[3] Open Geospatial Consortium. <http://wwww.opengeospatial.org>.

[4] Spatial Data Infrastructure of Catalonia. <http://wwww.geoportal-idec.net>.

[5] Law 16/2005 on Geographic Information (in Spanish). <http://www.geoportal-idec.net/geoportal/cas/docs/Resumen%20Ley%2016_2005.pdf>.

[6] Cartographic Institute of Catalonia. <http://www.icc.cat/>.

[7] M. Craglia, and M. Campagna (Editors). "Advanced Regional Spatial Data Infrastructures in Europe". 2009. <http://sdi.jrc.ec.europa.eu/ws/Advanced_ Regional_SDIs/arsdi_report.pdf>.